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Telink Qualification Report:- TLR9228HAR

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Brief:

This document lists reliability test conditions and result of specified product, Guarantee the quality of products through relevant reliability tests.



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Revision History

Version	Major Changes	Date	Author
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Reliability Qualification Report for TLR9228HAR

1. Reliability test summary

Stress	Total sample size	Number of Lots	Accept criteria	Test method	Test conditions
HTOL	77	3	0 Fails	JESD22-A108 JESD85	125°C/1.1VCC/1000H
LTOL	77	1	0 Fails	JESD22-A108	-40°/1.1VCC/1000H
Preconditioning	77*items	3	0 Fails	JESD22-113 J-STD-020	SAM-TC-Baking-Soaking-Reflow-SAM
HAST with Precon	77	3	0 Fails	JESD22-A110	130°C/85%RH /33.3psig/96hrs/Vmax
Unbiased HAST with Precon	77	3	0 Fails	JESD22-A118	130°C/85%RH /33.3psig/96hrs
PCT with Precon	77	3	0 Fails	JESD22-A102	121°C, 100%RH, 205 kPa, 96hrs
TCT with Precon	77	3	0 Fails	JESD22-A104	-65°C to 150°C,0.5H/500cycle
HTSL	77	3	0 Fails	JESD22-A103	150°C /1000hrs
SD	15	3	>95% lead coverage	JESD22-B102	Steam aging:8H;245°C,5s
BPS	30 bonds /5 units	1	CPK >1.67	MIL-STD-883	Characterization
BS	30 bonds /5 units	1	CPK >1.67	JESD22-B116	Characterization
NVCE	77	3	0 Fails	JESD22-117	Ta=25°C/85°C,Vmax, 1k/10k/100k cycling
PCHTDR	77	3	0 Fails	JESD22-117	Ta=125°C, 500h
UCHTDR	77	3	0 Fails	JESD22-117	Ta=150°C, 1000h
LTDR	77	3	0 Fails	JESD22-117	Ta=25°C, Vmax,500h
ESD-HBM	pin combination*3	1	0 Fails	JESD22A-114	±2000V
ESD-CDM	6	1	0 Fails	JESD22C-101	±500V
Latch-Up	9	1	0 Fails	JESD78	±100mA/1.5*Vmax
ED	10	3	As datasheet	JESD86	Datasheet

Moisture Sensitivity Level Test flow & Condition:

Electrical test → SAT → TC (-40 °C ~ 60 °C for 5 cycles) → Bake(125 °C ,24Hrs) → Soaking Level 3 (30 °C,60%RH,192Hrs) → Reflow(260 °C,3 Cycles) → Electrical Test → SAT



2 Introduction

In order to meet the most stringent market demands for high quality and reliability semiconductor components, Telink maintains a strict reliability program in all products. The purpose of this report is to give an overview of the reliability status of TLSR9228HAR. Accelerated tests are performed on product, and then the results are extrapolated to standard operating conditions in order to calculate and estimate the component's failure rate.

3 Reliability

Many stress tests have been standardized in such documents as JESD471. From these standards, Telink has selected a series of tests to ensure that reliability targets are being met. These tests, including life test, environment test, ESD test and latch-up test, are discussed in the following sections.

3.1 Sample preparation Flow

CP → Assembly QFN48 → FT → Sampling Good Parts for Reliability test

3.2 Life test

The HTOL / LTOL test is configured to bias the operating nodes of the device samples. The devices may be operated in a dynamic operating mode. Typically, several input parameters may be adjusted to control internal power dissipation. These include: supply voltages, clock frequencies, input signals, etc., that may be operated even outside their specified values, but resulting in predictable and nondestructive behavior of the devices under stress. The particular bias conditions should be determined to bias the maximum number of potential operating nodes in the device. The HTOL test is typically applied on logic and memory devices. The LTOL test is intended to look for failures caused by hot carriers, and is typically applied on memory devices or devices with submicron device dimensions..

3.2.1 Test flow

HTOL Test Flow

B/I 168Hrs(125°C,1.1*Vint) → Electrical Test → B/I 500Hrs(125°C,1.1*Vint) →
Electrical Test → B/I 1000Hrs(125°C,1.1*Vint) → Electrical Test



LTOL Test Flow

B/I 168Hrs(-40℃,1.1*Vint) → Electrical Test → B/I 500Hrs(-40℃,1.1*Vint) →
Electrical Test → B/I 1000Hrs(-40℃,1.1*Vint) → Electrical Test

3.2.2 Test Criteria

Test Item	Reference Standard	Test Condition	Test Times	Accept Criteria	Status
HTOL-1000Hrs	JESD22-A108	Vcc=1.1*Vint	1000hrs	0/231	Pass
		Ta =125℃			
LTOL-1000Hrs	JESD22-A108	Vcc=1.1*Vint	1000hrs	0/77	Pass
		Ta =-40℃			

3.2.3 Failure Rate Calculation and Test Result

The life test is performed for the purpose of accelerating the probable electrical and physical weakness of devices subjected to the specified conditions over an extended time period.

Most integrated circuit failure mechanisms are based on physical or chemical reactions. These reactions are accelerated by temperature and can be modeled using the Arrhenius equation. The acceleration factor (AF) between any two temperatures may be calculated as follows:

:

$$AF_{(T_1-T_2)} = e^{\frac{Ea}{k}(\frac{1}{T_1} - \frac{1}{T_2})}$$

Parameter	Description	Value
E	natural log	/
Ea	activation energy in electron volts	0.7 eV
k	Boltzmann's constant	8.62 x 10-5 eV/K
T1	use temperature	55℃



T2	stress temperature	125°C
AF	acceleration factor	77.823

Next, a Chi square approximation of the mature life failure rate can be made using the following information:

$$\text{Failure rate (X}^2\text{)} = \frac{X^2_{(2f+2,\alpha)}}{2*n*T*AF}$$

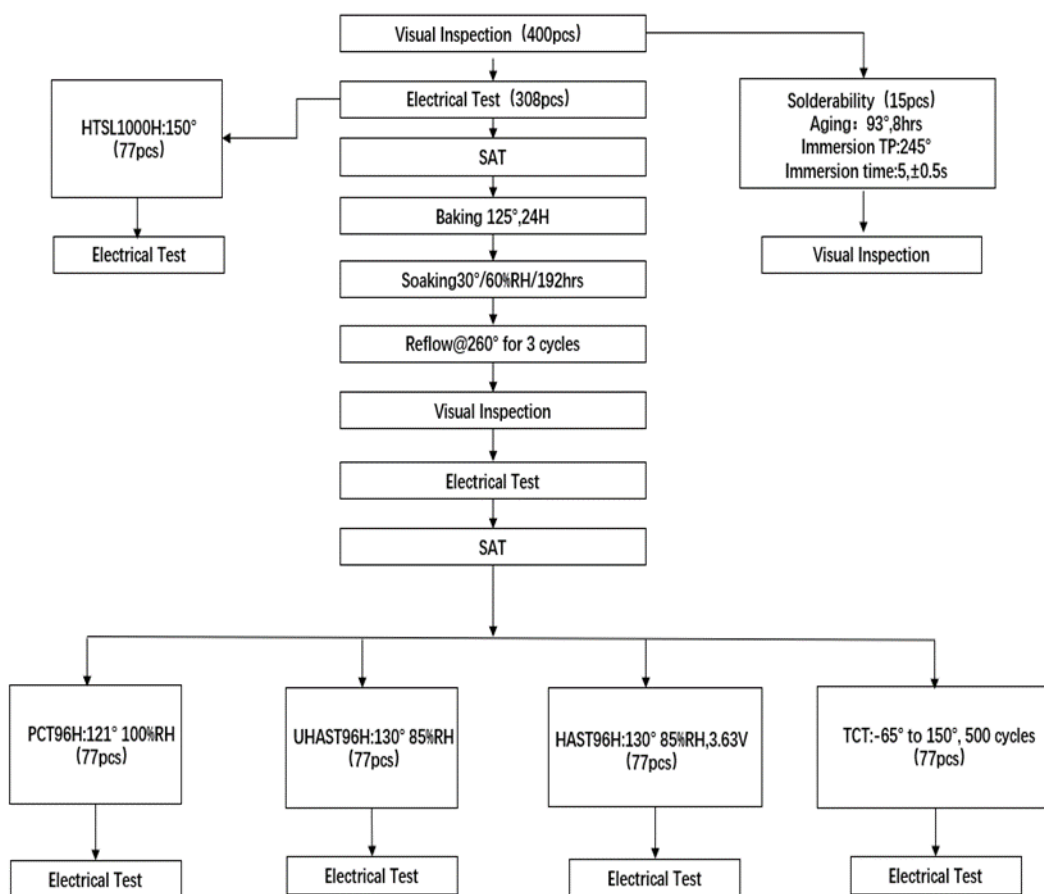
Parameter	Description	Value	
f	number of failures	0	
α	1 – confidence level	Confidence level 60%	Confidence level 90%
n	quantity tested	231	
T	test duration (hours)	1000Hr	
AF	acceleration factor	108.249	
MTTF	Mean Time To Failure	2.729*10 ⁷ Hr.	1.086*10 ⁷ Hr.
FIT	Failure rate	36.64	92.08



3.3 Environment Test

The purpose of environmental test is to evaluate the ability of semiconductor device to withstand the temperature stress, humidity stress, electrical stress or any combination of these. It can reveal not only the package quality issue but also the possible error in wafer process or chip design interacting with the assembly process.

3.3.1 Test Flow





3.3.2 Test Condition and Time

3.3.2.1 Moisture Sensitivity Test

The purpose of moisture sensitivity test is to identify the classification level of no hermetic solid state surface mount devices(SMDS) that are sensitive to moisture induced stress so that they can be properly packaged, stored, and handled to avoid subsequent thermal and mechanical damage during the assembly solder reflow attachment and/or repair operation.

Test Item	Test Condition (Level III)	Test Time
Temp. Cycle	-40°C ~ 60°C	5Cycles
Bake	125°C	24Hrs
Unbiased Temp-Humidity Soak	30°C, 60%R.H.	192Hrs
Convection Reflow	<div><p>IR REFLOW PROFILE FOR 260 - 0 / +5°C (Pb-Free)</p><p>TEMP (°C)</p><p>Max 265 260 255 230 217 190 180</p><p>Max 3 °C/S</p><p>Max 6 °C/S</p><p>TIME (S)</p><p>(a) Preheat Temp. = 60~120 seconds Max. (b) Temp. maintained above 217°C = 60~150 seconds (c) Temp. maintained above 230°C = 30~60 seconds (d) Temp. maintained above 255°C = 20~40 seconds (e) Peak Temp. Range = 260(-0/+5)°C & Max. 20 seconds P.S. Time 25°C to Peak Temp. = 8 minutes Max.</p></div>	3Cycles



3.3.2.2 High-Temperature Storage Life Test

The high-temperature storage life test measure device resistance to a high temperature environment that simulates a storage environment. The stress temperature is set to 150°C in order to accelerate the effect of temperature on the test samples. In the test, no voltage bias is applied to the devices.

Test Item	Test Condition	Test Time
HTST	150 °C	1000Hrs

3.3.2.3 Pressure Cooker Test

The pressure cooker test is an environment test that measures device resistance to moisture penetration and the effect of galvanic corrosion. The stress conditions for the pressure cooker are 121°C,100% relativity humidity, and 2.05atm pressure. Samples of surface mount devices are subjected to preconditioning and a final electrical test prior to the pressure cooker test

Test item	Test Condition	Test Time
PCT	121 °C,100%RH,2.05atm	96Hrs

3.3.2.4 Unbiased Highly Accelerated temperature and humidity Stress Test

The unbiased highly accelerated stress test is performed for the purpose of evaluating the reliability of non-hermetically packaged solid-state devices in humid environments. It employs temperature and humidity under non-condensing conditions to accelerate. The stress condition of the HAST are 130 °C,85% relativity humidity,2.3atm pressure. Samples of surface mount devices are subjected to preconditioning and a final electrical test prior to the highly-accelerated temperature and humidity stress test.

Test item	Test Condition	Test Time
UHASt	130 °C,85%RH,2.3atm,unbiased	96Hrs

3.3.2.5 Highly Accelerated temperature and humidity Stress Test

The Highly-Accelerated Temperature and Humidity Stress Test is performed for the purpose of evaluating the reliability of non-hermetic packaged solid-state devices in humid environments. It employs severe conditions of temperature, humidity, and bias which accelerate the penetration of moisture through the external protective material (encapsulant or seal) or along the interface between the external protective material and the metallic conductors which pass through it. The stress



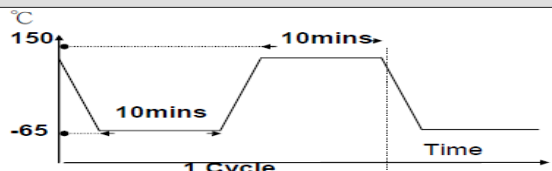
usually activates the same failure mechanisms as the “85/85” Steady-State Humidity Life Test (JEDEC Standard No. 22-A101).

Test item	Test Condition	Test Time
HAST	130℃,85%RH,2.3atm,3.63V	96Hrs

3.3.2.6 Temperature Cycling Test

The purpose of temperature cycling test is to study the effect of thermal expansion mismatch among the different components within a specific die and package system. The cycling test system has a cold dwell at -65℃ and a hot dwell 150℃,and it employs a circulating air environment to ensure rapid stabilization at a specified temperature. During temperature cycling test, devices are inserted into the cycling test system and held at cold dwell for 10 minutes, then the devices are heated to hot dwell for 10 minutes. One cycle includes the duration at both extreme temperature and the two transition times.

The transition period is less than one minutes at 25℃ Samples of surface mount devices must first undergo preconditioning and pass a final electrical test prior to the temperature cycling test.

Test Item	Test Condition	Test Time
TCT		500Cycles

3.3.2.7 Solderability Test

The purpose of this method is to provide a means of determining the solderability of device package terminations that are intended to be joined to another surface using lead-(pb-) containing or pb-free solder for the attachment.

Test item	Test Condition	Sample	Status
Solderability	Steam aging:8H;245℃, 5s	45	Pass



3.3.3 Test Criteria and Result

The following table shows the test results and reference standard of environmental test. The test status and results of TL9228HAR are also presented in the table. All pass from these test results mean that Telink products are much more durable in most of their service environment.

Test Item	Reference Standard	A/R Criteria	Failure/S.S	Status	Failure Mode
Moisture Sensitivity	JESD22-A113	0/1	0/308*3	Pass	NA
HTST	JESD22-A103	0/1	0/77*3	Pass	NA
TCT	JESD22-A104	0/1	0/77*3	Pass	NA
PCT	JESD22-A102	0/1	0/77*3	Pass	NA
UFAST	JESD22-A118	0/1	0/77*3	Pass	NA
HAST	JESD22-A110	0/1	0/77*3	Pass	NA
SD	JESD22-B102	0/1	0/15*3	Pass	NA

3.4 Package characterization

The purpose of bond pull test is to measure bond strengths, evaluate bond strength distributions, or determine compliance with specified bond strength requirements of the applicable acquisition document. This test may be applied to the wire-to-die bond, wire-to-substrate bond, or the wire-to-package lead bond inside the package of wire-connected microelectronic devices bonded by soldering, thermocompression, ultrasonic, or related techniques. It may also be applied to bonds external to the device such as those from device terminals-to-substrate or wiring board or to internal bonds between die and substrate in non-wire-bonded device configurations such as beam lead or flip chip devices.

The wire bond shear test is destructive. It is appropriate for use in process development, process control and/or quality assurance.

Test Item	Reference Standard	A/R Criteria	Sample	Status
BPS	MIL-STD-883	CPK >1.67	30 bonds /5 units	Pass
BS	JESD22-B116	CPK >1.67	30 bonds /5 units	Pass



3.5 ESD test

Electrical discharge into semiconductor product is one of the leading causes of devices failure in the customer's manufacturing process. Telink performs the ESD test to ensure that the performance of TL9228HAR will not be degraded to an unacceptable level by exposure to a succession of electrostatic discharge. The test methods and test results are show in following table:

Test Item	Test Method			Fail/Pass
	Reference Standard	Criteria	Sample	
HBM	JESD22A-114	+/-2KV	15ea	0/15
CDM	JESD22C-101	+/-500V	6ea	0/6

3.6 Latch-up Test

CMOS products can be prone to over-voltage exceeding the maximum device rating if the parasitic p-n-p-n SCR (Silicon-controlled rectifier) are improperly biased. When the SCR turn on, it draws excessive current and causes products being damaged by thermal runaway. The following table shows the latch-up test method and the test result of no failure.

Latch-Up	Test Item	Mode	Spec	Class I	Samples	Fail/Pass
	I-Test	Positive	+100mA	I:25°	3ea	0/3
		Negative	-100mA		3ea	0/3
	V _{supply} Over Voltage	Positive	1.5Vmax		3ea	0/3



3.7 NON-VOLATILE MEMORY

The defines the qualification requirement for NVM device. program Post Cycling High Temperature Data Retention (PCHTDR) and Low Temperature Data Retention (LTDR) samples with a topological checkboard pattern where bit is surrounded by its complement. Memory Cycling Endurance (NVCE) must be performed at two temperatures at 25°C and 85°C. It is critical that Error Correction Code (ECC) is turned off.

Test Item	Reference Standard	A/R Criteria	Failure/S. S	Status	Failure Mode
NVCE	JESD22-117	0/1	0/77*3	Pass	NA
PCHTDR	JESD22-117	0/1	0/77*3	Pass	NA
UCHTDR	JESD22-117	0/1	0/77*3	Pass	NA
LTDR	JESD22-117	0/1	0/77*3	Pass	NA

3.8 Electrical Parameter Assessment

The purpose of this test method is to define methods for obtaining characterization, electrical distribution, and parametric shift data for electrical parameters on integrated circuits. The intent of this method is to assess the part's capability to function within the specification parameters over normal process variations, time, and/or the anticipated application environment.

Test Item	Reference Standard	A/R Criteria	Sample	Status
ED	JESD86	As datasheet	10*3 lot	Pass



4 Conclusion

Reliability test is to ensure the ability of a product in order to perform a required function under specific conditions for a certain period of time. Through those tests, the devices of potential failure can be screened out before shipping to the customer. At the same time, the test results are fed back to process, design and other related departments for improving product quality and reliability.

According to the life time test data, the long-term 1000Hrs failure rate (=the normal operation 1-10 year) of TL9228HAR is equal to 36.64 FITS at $T_a=125^{\circ}\text{C}$ and $V_{cc}=3.63\text{V}$ with 60% confidence level and 92.08 FITS at $T_a=125^{\circ}\text{C}$ and $V_{cc}=3.63\text{V}$ with 90% confidence level. The results of environmental test, ESD test and latch-up test also ensure that the TL9228HAR is manufactures under a precise control of quality by Telink and its subcontractors. Thus, this experiment based on the Telink reliability test standard for above test items can all pass.

With the extensive research and development activities and the cooperation of all departments, Telink continuously sets and maintains higher standard of quality and reliability to satisfy the future daman of its customers.